

ΔS : change in entropy.

ΔG : change in Gibbs free energy.

Note: ΔS is a part of ΔG .

So,

as randomness $\uparrow \Rightarrow \Delta S \uparrow$

State of matters

Solid: low S due to hardness of attraction forces.

Liquid:

Gas: High S due to weakness of attraction forces.

Spontaneous Reaction:

- A reaction that happens without any external conditions like: Ice to water.

non-Spontaneous Reaction:

- A Reaction that happens with (by) the effect of external conditions.

Written By : Hady Tarek

Section 45

AsuEng.com

→ Second law of thermodynamics

- every spontaneous change is accompanied by increase in S

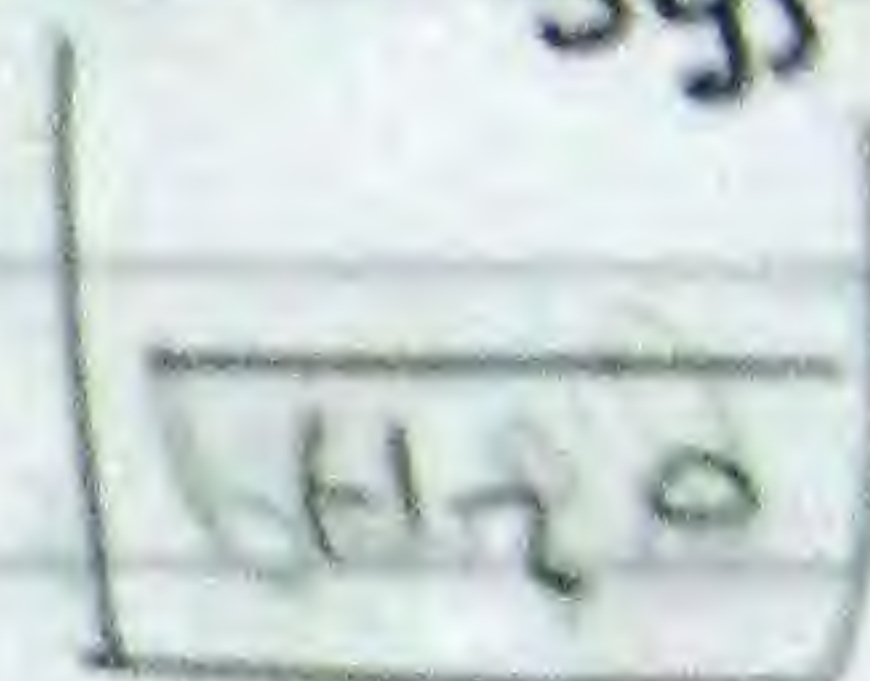
Solid \rightarrow liquids
low S high S
 $\Delta S = +ve$
"spontaneous"

liquid \rightarrow solid
high S low S
 $\Delta S = -ve$
"non-spontaneous"

- system: The matter which I study $\rightarrow \Delta S_{sys}$.

AT figure

H₂O is the system.



- surroundings: the objects that surround the system

$\rightarrow \Delta S_{surr}$

AT figure

All conditions and the container.

$$\Delta S_{Total} = \Delta S_{system} + \Delta S_{surrounding}$$

liquid \rightarrow solid
 $\Delta S_{sys} = -ve$

$\Delta S_{surr} = +ve$

→ As $\Delta S_T \uparrow = +ve \Rightarrow$ spon.

$\Rightarrow \Delta G = -ve, \neq 0$

→ As $\Delta S_T = -ve \Rightarrow$ non-spon.

$\Rightarrow \Delta G = 0$

→ As $\Delta S_T \downarrow = 0 \Rightarrow$ equilibrium

$\Rightarrow \Delta G = +ve, \neq 0$

ex Water \rightarrow ice $\frac{H\Delta}{T}$ at ; $+1^\circ\text{C}$, zero, -1°C

$(+1^\circ\text{C}) : \Delta S_{\text{sys.}} = -\text{ve} , \Delta S_{\text{surr.}} = +\text{ve}$

$\therefore \Delta S_T = -\text{ve}$

\therefore Reaction is non-spontaneous.

$(-1^\circ\text{C}) : \Delta S_{\text{sys.}} = -\text{ve} , \Delta S_{\text{surr.}} = +\text{ve}$

$\therefore \Delta S_T = +\text{ve}$

\therefore Reaction is spontaneous.

$(0^\circ\text{C}) : \Delta S_{\text{sys.}} = -\text{ve} , \Delta S_{\text{surr.}} = +\text{ve}$

$\therefore \Delta S_T = \text{zero}$

Note : $\rightarrow \Delta S_{\text{sys.}} = -\text{ve} , \Delta S_{\text{surr.}} = +\text{ve}$ at all

conditions as it depends on randomness.

\rightarrow The energy that the system release the surrounding absorb it?

$\rightarrow T$: is +ve at all conditions.

ΔG

- change in Gibbs free energy
- used to know that reaction is (spontaneous or non spontan.).

$\Delta G = -T \Delta S_T$

$$\boxed{\Delta S_{\text{surr}} = - \frac{\Delta H}{T}} \quad (1)$$

$$\Delta S_T = \Delta S_{\text{sys}} + \Delta S_{\text{surr.}} \quad (2)$$

By (1), (2)

$$\Delta S_T = \Delta S_{\text{sys}} - \frac{\Delta H}{T} \times (-T)$$

$$-T \Delta S_T = -T \Delta S_{\text{sys}} + \Delta H$$

$$\therefore \boxed{\Delta G = -T \Delta S_T}$$

$$\therefore \boxed{\Delta G = \Delta H - T \Delta S_{\text{sys}}} \Rightarrow \text{Imp.}$$

Note: we can know that Reaction is (spont. or non. spont.) by ΔS or ΔG . but ΔG is more practical than ΔS at it is hard to calculate ($\Delta S_{\text{sys.}}$, $\Delta S_{\text{surr.}}$).



$$\Delta S_{\text{sys.}} = \Delta S_p - \Delta S_r$$

Note: Any Boiling point or Freezing point represent the condition of equilibrium.

(Boiling of water) $\rightarrow 100^\circ\text{C}$

(Freezing of water) $\rightarrow 0^\circ\text{C}$

$$\boxed{\Delta H_{\text{reaction}} = \Delta H_{f(P)} - \Delta H_{f(R)}}$$

$\Delta G_f(\text{element}), \Delta H_f(\text{any element}) = 0 \Rightarrow \text{Imp.}$

$$\boxed{\Delta G_{\text{reaction}} = \Delta G_{f(P)} - \Delta G_{f(R)}}$$

measured	ΔH	measured	ΔH°
at	ΔE	at	ΔE°
any	ΔS	standard	ΔS°
conditions	ΔG	conditions	ΔG°

$P = 1 \text{ atm}$
 $T = 25^\circ \text{C}$

$$\rightarrow \Delta G = \Delta H - T\Delta S \quad \rightarrow \Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

\rightarrow Note To calculate any term of the law
 $(T = 298^\circ \text{K})$

- To calculate the normal Boiling point
 $(\Delta G = 0)$.

ΔH : $\Delta H = \Delta E + \Delta n RT \Rightarrow \text{Solid or liquid or gas.}$
 $\Delta H = \Delta H_f(P) - \Delta H_f(R) \Rightarrow \text{Compound or element}$
 $\Delta H = \Delta G + T\Delta S$

ΔE : $\Delta H = \Delta E + \Delta n RT$
 $\Delta E = q_v \Rightarrow \text{Per one mole.}$
 $\Delta n = n_p - n_r \Rightarrow \text{Gas.}$
 $\Delta E = q - w.$

ΔS : $\Delta S = \Delta S_p - \Delta S_r \Rightarrow (\text{Element} \neq 0)$

ΔG : $\Delta G = \Delta G_f(P) - \Delta G_f(R)$
 $\Delta G = \Delta H - T\Delta S.$

Note Heat of Reaction : $\Delta H_{\text{reaction}}$.